Concentrations of dissolved thorium and protactinium isotopes (232Th, 230Th, 231Pa) in seawater collected during the Indian GEOTRACES Transect (SK324; GI05) in September-October 2015

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Project
» Collaborative Research: U.S. GEOTRACES Arctic Section: Thorium-230, Thorium-232, and Protactinium-231 tracers of trace element supply and removal. (GEOTRACES Arctic Th Pa)
» Collaborative Research: US GEOTRACES Pacific Meridional Transect: Sources and Sinks of Neodymium Isotopes and Rare Earth Elements (GP15 Nd isotopes)

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Abstract
This dataset contains concentrations of dissolved thorium and protactinium isotopes (232Th, 230Th, 231Pa) in seawater collected during the Indian GEOTRACES Transect (SK324; GI05; September 22 – October 21, 2015), in the western Indian Ocean, on the ORV Sagar Kanya. Similar data from SK312 (GI02) are available in a separate dataset. These data were generated at the Lamont-Doherty Earth Observatory of Columbia University (LDEO).

Table of Contents

- Coverage
- Dataset Description
  - Methods & Sampling
  - Data Processing Description
  - BCO-DMO Curation Notes
- Data Files
- Related Publications
- Related Datasets
- Parameters
- Instruments
- Deployments
- Project Information
- Funding

Coverage

Location: Western Indian Ocean
Spatial Extent: **N**:18.175 **E**:65.001 **S**:8.3 **W**:58.628
Temporal Extent: 2015-09-30 - 2015-10-09

Methods & Sampling

Seawater samples were collected onboard ORV Sagar Kanya during the fall monsoon period (SK-324/GI-05; September 22– October 21, 2015) under the GEOTRACES-India program (Subha Anand et al, 2018; Chinni et al., 2022). Samples were obtained using a standard CTD rosette (Sea-Bird Scientific) with 10-liter (L) Niskin bottles from the near-surface to a maximum depth of 3700 meters (m). Note that the westernmost station (SK324-13) is near (< 100 kilometers (km)) shallow topography (< 1000 m). In the field, samples were filtered (0.2 micrometers (µm)), stored in acid-cleaned (10% HCl, trace metal grade) low-density polyethylene (LDPE) cubitainers (10 L) or bottles (4 L), and acidified to pH ~2 (6 M HCl, Optima grade).

Each batch of samples included 12-13 seawater samples, 1 intercalibrated working standard, 1 seawater standard, 2 procedural blanks, and 1-2 column blanks. All open samples were handled inside a high-efficiency particulate air (HEPA) laminar flow bench (Envirco 100 Plus). All Teflon tubes and vials were soaked in soap solution for at least 24 hours, acid-soaked (8 M HNO3) at 160 degrees Celsius (°C) for 2 days, and rinsed with ultra-pure water (Milli-Q). All reagents were Optima grade. Quality control was tested by intercomparison of the intercalibrated working standard SW STD 2010-1 (Anderson et al., 2012).

Seawater samples (~4 kilograms (kg)) were transferred to acid-cleaned LDPE cubitainers (5 L; Hedwin Corporation) and further acidified to pH 1.6-1.9 using Optima 6 M HCl. Weighed aliquots of 229Th spike (~1 picogram (pg)) and a protactinium isotope (233Pa) spike (100-300 femtograms (fg)) were added to the samples, standards, and procedural blanks. Additionally, purified FeNO3 carrier (30-50 milligrams per milliliter (mg/mL) Fe) was added to the samples, standards, and blanks. After allowing the spikes to equilibrate for at least 24 h, concentrated NH4OH was added to adjust the pH to 8.5-8.7 in order to precipitate Fe(OH)3. Samples were swirled every few hours when possible and the precipitates were allowed to settle for 1-2 days.

After siphoning much of the overlying seawater in the cubitainers to waste, the settled Fe precipitates were transferred to polycarbonate centrifuge bottles (250 mL; Fisher Scientific) for centrifugation (IEC CL30, Thermo Scientific) at 3000 RPM for 27 minutes. Fe precipitates were then transferred to Teflon centrifuge tubes (50 mL; Savillex) for centrifugation at 3000 RPM for 12 minutes. All cubitainers and centrifuge bottles were rinsed with dilute NH4OH to remove major seawater ions and Fe precipitates before transfer to the centrifuge tubes. The supernatant was decanted from the centrifuge tubes and pellets were qualitatively screened using NaI detection to check Pa yields by gamma counting. The Fe pellets were then dissolved in concentrated HNO3 (16 M) and transferred to Teflon vials (15 mL; Savillex). Centrifuge tubes were rinsed with concentrated HNO3. Concentrated HClO4 was added to the vials, which were heated overnight at 100° C to form a Si crust.

High-temperature digestion was performed in order to remove organic matter and amorphous Si from the precipitates. Samples were heated at 180-210°C to fume HClO4. Concentrated HF was added 2-3 times at high temperature to dissolve the Si crust. Concentrated HNO3 and HClO4 were added to the vials and heated to fume HClO4. Digested samples were taken up in dilute HCl and transferred back to the centrifuge tubes. Vials were rinsed with Milli-Q water. Concentrated NH4OH was added to the centrifuge tubes in order to precipitate Fe(OH)3 again. Precipitates were washed with Milli-Q water and centrifuged at 3000 RPM for 12 minutes. After decanting the supernatant, the Fe pellet was dissolved in concentrated HNO3 and transferred back to the 15 mL vial. Centrifuge tubes were rinsed with concentrated HNO3. The seawater standard and column blanks were prepared in concentrated HNO3 in 15 mL vials. All samples (including the seawater standard and column blanks) were heated to dryness at 150-180° C.

Samples were then taken up in concentrated HCl. Polypropylene anion-exchange columns (Bio-Rad Econo-Column) containing 1 mL of Bio-Rad resin (AG1-X8, 100-200 mesh size) and porous polyethylene frits (45 µm) were prepared for initial column separation. Columns were drained and rinsed with a mixed solution of concentrated HCl and HF (0.14 M; to remove Th and Pa from the resin), Milli-Q water (to remove HF), and concentrated HCl (to precondition the columns). Samples were loaded onto the columns, rinsed with concentrated HCl, and drained to Teflon vials (7 mL; Savillex) to collect the unpurified Th fractions. Columns were then rinsed with a mixed solution of concentrated HCl and HF (0.14 M) and drained to new 7 mL vials to elute the unpurified Pa fractions. Vials were capped and analyzed using NaI detection to ensure that Pa did not contaminate the Th fractions. Columns were cleaned using dilute HCl (to remove Fe and U from the resin). Concentrated HNO3 and HClO4 were added to the vials containing the Th and Pa fractions to remove organic matter eluted from the resin. All vials were heated overnight at 100° C to dry down the Th and Pa column elutions to a drop of HClO4.

The Th fractions were then taken up in HNO3, while the Pa fractions were taken up in concentrated HCl. Anion-exchange columns were conditioned for Th purification by draining the columns filled with dilute HCl and rinsing with HNO3 (8 M). The Th fractions were loaded onto the columns, and the vials and columns were rinsed with HNO3 (8 M). After acid-cleaning the Th vials (8 M HNO3), concentrated HCl was added to the columns to elute

the purified Th fractions. Columns were cleaned and reconditioned for the purified Pa column by rinsing with Milli-Q water, a mixed solution of concentrated HCl and HF (0.14 M), Milli-Q water again, and concentrated HCl. The Pa fractions were loaded onto the columns and rinsed with concentrated HCl. After acid-cleaning the Pa vials (8 M HNO3), a mixed solution of concentrated HCl and HF (0.14 M) was added to the columns to elute the purified Pa fractions into the cleaned Pa vials. Concentrated HNO3 and HClO4 were added to the Th and Pa vials, which were heated overnight at 100 C. All samples were dried down to a drop of HClO4 at ~180° C and taken up in run solution (0.16 M HNO3, 0.028 M HF). Pa vials were counted using a NaI detector to determine qualitative recovery. Samples, in run solution, were then transferred to acid-cleaned microcentrifuge tubes and capped for storage until run on the ICP-MS.

Concentrations of 232Th, 230Th, and 231Pa were calculated by isotope dilution, relative to the calibrated tracers 229Th and 233Pa added at the beginning of sample processing. Analyses were carried out on a Thermo-Finnigan ELEMENT XR Single Collector Magnetic Sector ICP-MS. To ensure the highest possible sensitivity, the instrument was equipped with a high-performance interface pump (Pfeiffer OnTool Booster 150 "Jet Pump"), high-performance sample (Jet) and skimmer (X) cones, and a desolvating nebulizer, CETAC Aridus I. For increased signal stability, an Elemental Scientific (ESI) Continuum syringe pump system was employed for sample introduction to the Aridus I. Sample uptake rate was ~100 microliters per minute (µL/min) and sample analysis time was on the order of 3 minutes.

All measurements were made in low-resolution mode (M/Δm ≈300), peak jumping in Escan mode across the central 5% of the flat-topped peaks. Measurements were made on a MasCom discrete dynode Secondary Electron Multiplier (SEM). 229Th, 230Th, 231Pa, and 233Pa were measured in Counting mode, while the 232Th signal was large enough that it had to be measured in Analog mode. Two solutions of SRM129, a natural uranium (U) standard, were run multiple times throughout each run. One solution was in a concentration range where 238U and 235U were both measured in Counting mode, allowing us to determine the mass bias/amu (values varied from -0.5%/amu to +0.2%/amu). In the other, more concentrated solution, 238U was measured in Analog mode and 235U was measured in Counting mode, yielding a measurement of the Analog/Counting Correction Factor (typical values varied from 0.9 to 1.1). These corrections assume that the mass bias and Analog/Counting Correction Factor measured on U isotopes can be applied to Th and Pa isotope measurements. Each sample measurement was bracketed by measurement of an aliquot of the run solution (0.16 M HNO3/0.026 M HF), which was used to correct for the instrumental background count rates. To correct for tailing of 232Th into the minor Th and Pa isotopes, a set of external 232Th standards were run at concentrations bracketing the expected 232Th concentrations in the samples. The analysis routine for these standards was identical to the analysis routine for samples, so we could see the changing beam intensities at the minor masses as we increased the concentration of the 232Th standards. The 232Th count rates in our Pa fractions were quite low after separation of Pa from Th during anion-exchange chromatography, reflecting mainly reagent blanks, compared to the 232Th signal intensity in the Th fraction. The regressions of 229Th, 230Th, 231Pa, and 233Pa signals as a function of the 232Th signal in the standards was used to correct for tailing of 232Th in samples. Only in rare cases was a tail correction of 232Th on 231Pa and 233Pa necessary, while it was almost always the case that tail corrections of 232Th on 229Th and 230Th were performed.

Blank corrections were made using the average value of the procedural blanks analyzed with each batch of samples. The average procedural blanks, combining runs for GI02 and GI05, for 232Th, 230Th, and 231Pa are 0.021±0.009 picomoles (pmol), 0.19±0.16 microBecquerel (µBq) and 0.18 ± 0.23 µBq, respectively. The limit of detection (LOD) is the smallest quantity of each isotope in samples that can reliably be detected or that can be statistically distinguished from a procedural blank. The LOD was considered to be two standard deviations above the average of the procedural blanks.

Data Processing Description

The reported errors for radionuclide concentrations represent the propagation of one sigma errors based on the standard isotope ratios collected by ICP-MS, estimated error in the 229Th or 233Pa spike concentration, and the blank correction of the individual isotopes. As noted above, samples were corrected for blanks using the procedural blank analyzed during the same sample batch.

Samples were analyzed 2 to 3 years after collection. A correction was made to account for the ingrowth of 230Th and 231Pa due to the decay of the natural 234U and 235U preserved in the acidified samples during the period of time between sample collection and U-Th/Pa separation during anion exchange chromatography. Thus, the reported 230Th and 231Pa concentrations have been corrected to represent their concentrations at the time of sampling. U concentrations were estimated using the bottle salinity (S) measured from the CTD and the U-Salinity relationship in seawater (Owens et al., 2011), [U] = (0.100 * S – 0.326) ng U (g seawater)-1. We

used seawater U-isotopic compositions of 234U/238U = 1.1468 activity ratio (Andersen et al., 2010), and 238U/235U = 137.824 mole ratio (Weyer et al., 2008), to calculate [234U] and [235U] respectively based on [U].

Individual uncertainties for protactinium and thorium were calculated to include contributions from blank correction, standard error of the ratios of the analysis (typically close to counting statistics) and spike calibration. For protactinium we also included assessment of the correction from the yield correction, mass bias and instrument background. In order to assess the reproducibility of the procedure, repeat analyses were performed on the GEOTRACES SW STD 2010-1 artificial seawater standard (Anderson et al., 2012). For standards run alongside these seawater samples, the reproducibility for each isotope was 2.8% for 232Th, 2.0% for 230Th, and 9.9% for 231Pa.

Quality Flags:
SeaDataNet quality flags have been assigned to all measured and derived parameters. More information on SeaDataNet quality flags is available from GEOTRACES at https://www.geotraces.org/geotraces-quality-flag-policy/and from SeaDataNet at https://www.seadatanet.org/Standards/Data-Quality-Control. In summary:

0 = no quality control;
1 = good value;
2 = probably good value;
3 = probably bad value;
4 = bad value;
5 = changed value;
6 = value below detection;
7 = value in excess;
8 = interpolated value;
9 = missing value;
A = value phenomenon uncertain.

Concentrations below the limit of detection (LOD) are indicated as "nd" and flagged with "6". The missing data identifier, "nd", also refers to no data available when flagged with "9" (i.e., no analysis).

BCO-DMO Curation Notes

- Imported original file "GI05_SK324_Dissolved Th Pa Anderson.xlsx" into the BCO-DMO system.
- Renamed fields to comply with BCO-DMO naming conventions.
- Converted Start_Date_UTC field to YYYY-MM-DD format.
- Removed blank columns: Event_ID, Gear_ID, Start_Time_UTC, End_Date_UTC, End_Time_UTC, End_Latitude, End_Longitude, Rosette_Position, Sample_ID.
- Saved the final file as "931248_v1_gi05_dissolved_th_and_pa_isotopes.csv"

[table of contents | back to top]

Data Files

File	
931248_v1_gi05_dissolved_th_and_pa_isotopes.csv	(Comma Separated Values (.csv), 2.08 KB) MD5:2913e8cfc2b148d80b1560da8ee3413c
Primary data file for dataset ID 931248, version 1	

[table of contents | back to top]

Related Publications

Andersen, M. B., Stirling, C. H., Zimmermann, B., & Halliday, A. N. (2010). Precise determination of the open ocean 234U/238U composition. Geochemistry, Geophysics, Geosystems, 11(12). doi:10.1029/2010gc003318
Methods

Anderson, R. F., Fleisher, M. Q., Robinson, L. F., Edwards, R. L., Hoff, J. A., Moran, S. B., … Francois, R. (2012). GEOTRACES intercalibration of 230Th, 232Th, 231Pa, and prospects for 10Be. Limnology and Oceanography: Methods, 10(4), 179–213. doi:10.4319/lom.2012.10.179
Methods

Chinni, V., & Singh, S. K. (2022). Dissolved iron cycling in the Arabian Sea and sub-tropical gyre region of the Indian Ocean. Geochimica et Cosmochimica Acta, 317, 325–348. https://doi.org/10.1016/j.gca.2021.10.026
Methods

Owens, S. A., Buesseler, K. O., & Sims, K. W. W. (2011). Re-evaluating the 238U-salinity relationship in seawater: Implications for the 238U–234Th disequilibrium method. Marine Chemistry, 127(1-4), 31–39. doi:10.1016/j.marchem.2011.07.005
Methods

Subha Anand, S., Rengarajan, R., & Sarma, V. V. S. S. (2018). 234Th-Based Carbon Export Flux Along the Indian GEOTRACES GI02 Section in the Arabian Sea and the Indian Ocean. Global Biogeochemical Cycles, 32(3), 417–436. Portico. https://doi.org/10.1002/2017gb005847 https://doi.org/10.1002/2017GB005847
Methods

Weyer, S., Anbar, A. D., Gerdes, A., Gordon, G. W., Algeo, T. J., & Boyle, E. A. (2008). Natural fractionation of 238U/235U. Geochimica et Cosmochimica Acta, 72(2), 345–359. doi:10.1016/j.gca.2007.11.012
Methods

[table of contents | back to top]

Related Datasets

IsRelatedTo

Anderson, R. F., Fleisher, M. Q., Bausch, A., Leal, A., Chinni, V., Singh, S. K. (2024) **Concentrations of dissolved thorium and protactinium isotopes (232Th, 230Th, 231Pa) in seawater collected during the Indian GEOTRACES Transect (SK312; GI02) in April-May 2014.** Biological and Chemical Oceanography Data Management Office (BCO-DMO). (Version 1) Version Date 2024-07-02 doi:10.26008/1912/bco-dmo.930347.1 [view at BCO-DMO]

[table of contents | back to top]

Parameters

Parameter	Description	Units
Station_ID	Station ID number	unitless
Start_Date_UTC	Start date (UTC) of sample collection	unitless
Start_Latitude	Latitude at start of sample collection; negative values = South	decimal degrees
Start_Longitude	Longitude at start of sample collection; negative values = South	decimal degrees
Sample_Depth	Sample depth	meters (m)
CTDTMP	Temperature recorded by CTD (ITS-90)	degrees Celsius

CTDSAL	Salinity recorded by CTD (PSS-78)	PSU
Pa_231_D_CONC_BOTTLE_fro7kt	Concentration (or activity) of dissolved 231Pa from bottle samples	microBecquerel per kilogram (uBq/kg)
SD1_Pa_231_D_CONC_BOTTLE_fro7kt	One standard deviation of Pa_231_D_CONC_BOTTLE_fro7kt	microBecquerel per kilogram (uBq/kg)
Flag_Pa_231_D_CONC_BOTTLE_fro7kt	SeaDataNet quality flag for Pa_231_D_CONC_BOTTLE_fro7kt	unitless
Th_230_D_CONC_BOTTLE_inhsei	Concentration (or activity) of dissolved 230Th from bottle samples	microBecquerel per kilogram (uBq/kg)
SD1_Th_230_D_CONC_BOTTLE_inhsei	One standard deviation of Th_230_D_CONC_BOTTLE_inhsei	microBecquerel per kilogram (uBq/kg)
Flag_Th_230_D_CONC_BOTTLE_inhsei	SeaDataNet quality flag for Th_230_D_CONC_BOTTLE_inhsei	unitless
Th_232_D_CONC_BOTTLE_h66s3f	Concentration (or activity) of dissolved 232Th from bottle samples	picomoles per kilogram (pmol/kg)
SD1_Th_232_D_CONC_BOTTLE_h66s3f	One standard deviation of Th_232_D_CONC_BOTTLE_h66s3f	picomoles per kilogram (pmol/kg)
Flag_Th_232_D_CONC_BOTTLE_h66s3f	SeaDataNet quality flag for Th_232_D_CONC_BOTTLE_h66s3f	unitless

[table of contents | back to top]

Instruments

Dataset-specific Instrument Name	IEC CL30, Thermo Scientific
Generic Instrument Name	Centrifuge
Generic Instrument Description	A machine with a rapidly rotating container that applies centrifugal force to its contents, typically to separate fluids of different densities (e.g., cream from milk) or liquids from solids.

Dataset-specific Instrument Name	standard CTD rosette (Sea-Bird Scientific)
Generic Instrument Name	CTD Sea-Bird
Generic Instrument Description	A Conductivity, Temperature, Depth (CTD) sensor package from SeaBird Electronics. This instrument designation is used when specific make and model are not known or when a more specific term is not available in the BCO-DMO vocabulary. Refer to the dataset-specific metadata for more information about the specific CTD used. More information from: http://www.seabird.com/

Dataset-specific Instrument Name	10-L Niskin bottles
Generic Instrument Name	Niskin bottle
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

Dataset-specific Instrument Name	Thermo-Finnigan ELEMENT XR Single Collector Magnetic Sector ICP-MS
Generic Instrument Name	Thermo Scientific ELEMENT XR high resolution inductively coupled plasma mass spectrometer
Generic Instrument Description	A high-resolution (HR) inductively coupled plasma (ICP) mass spectrometer (MS) composed of a dual mode secondary electron multiplier (SEM) and a Faraday detector. The ELEMENT XR instrument has a dynamic range of 5 x 10^7 to 1 x 10^12 counts per second (cps), and allows simultaneous measurement of elements at concentrations over 1000 ug/g.

[table of contents | back to top]

Deployments

SK324

Website	https://www.bco-dmo.org/deployment/931258
Platform	ORV Sagar Kanya
Report	https://www.bodc.ac.uk/resources/inventories/cruise_inventory/reports/sagarkanya_sk324.pdf
Start Date	2015-09-22
End Date	2015-10-22
Description	Additional information about this cruise is available from BODC: https://www.bodc.ac.uk/resources/inventories/cruise_inventory/report/16180/

[table of contents | back to top]

Project Information

Collaborative Research: U.S. GEOTRACES Arctic Section: Thorium-230, Thorium-232, and Protactinium-231 tracers of trace element supply and removal. (GEOTRACES Arctic Th Pa)

Coverage: Western Arctic Ocean

NSF Award Abstract:
In support of the 2015 U.S.GEOTRACES Arctic expedition, this project will focus on the fate and distributions of naturally-occurring radioisotopes in the Arctic Ocean. Such information is useful for understanding why other chemical substances, both natural and man-made, occur where they do in the ocean. Like other national initiatives involved in the International GEOTRACES Program, the goals of this U.S. Arctic expedition are to identify processes and quantify fluxes that control the distributions of key trace elements and isotopes (TEI) in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions. Working at sea alongside a multi-institutional team of ocean trace element experts, investigators on this project will define regions of unusually high rates of TEI removal, anticipated to be located near basin margins and near the sea floor. By combining their measurements of naturally-occurring thorium and protactinium with TEI data collected by other participating investigators, they expect to be able to translate these rates into information that can be applied to other TEIs. Like most other participating investigators, this group will include graduate students as part of the research team and will participate in a variety of public educational outreach activities for Alaskan communities.

This study will undertake measurements of the dissolved and particulate concentrations of 230Th and 231Pa, two isotopes designated as key or critical to the success of the GEOTRACES program. Additionally the team will measure dissolved and particulate 232Th concentrations and analyze a limited number of aerosol samples, aerosol leachates, sea ice, melt pond water and surface sediments for these radionuclides. The work plan will be broken down into five tasks geared to: (1) determine the rates of boundary scavenging of 231Pa and 230Th associated with the particle-rich waters near the southern margin of the Canada Basin; (2) determine the rates of bottom scavenging of 231Pa and 230Th associated with nepheloid layers that are prevalent in the Arctic Ocean; (3) assess the contribution to scavenging in the Canada basin by MnO2-coated particles, formed during early diagenesis in organic-rich sediments surrounding the Arctic Ocean; (4) determine the rate of supply of lithogenic 232Th from margin sediments using information derived from 230Th; and (5) determine the rate of supply of lithogenic 232Th from sea ice, including the aerosols and ice-rafted sediments that they transport, by the combined study of 232Th and 230Th. The proposed work fulfills core scientific objectives defined in the U.S. GEOTRACES Arctic Implementation Plan.

Collaborative Research: US GEOTRACES Pacific Meridional Transect: Sources and Sinks of Neodymium Isotopes and Rare Earth Elements (GP15 Nd isotopes)

Coverage: North Pacific

NSF Award Abstract:
The goal of the international GEOTRACES program is to understand the distributions of trace chemical elements and their isotopes in the oceans. Neodymium (Nd) isotopes and rare earth elements (REE) are widely recognized for their utility as tracers of water transport and as indicators of the sources of trace elements to the oceans. Neodymium isotopes have been designated as "key parameters" to be measured on GEOTRACES expeditions. This project would measure Nd isotopes on a 2018 GEOTRACES expedition in the Pacific Ocean. The North Pacific is a particularly interesting place to measure Nd isotopes because North Pacific and North Atlantic deep waters represent the two end-members of deep ocean composition, and the few data available so far in the North Pacific differ from expectations based on mixing of known water types.

The US GEOTRACES Pacific Meridional Transect (PMT) from Tahiti to Alaska will play an important role in solving the "mystery" of North Pacific neodymium isotope ratios. The PMT is designed to extensively sample the oldest waters in the ocean, along with Alaskan coastal margins, volcanogenic sediments, the meridional dust gradient originating from volcanic arcs and the Asian and North American continents, and large gradients in biological productivity. The primary purpose of this project is to characterize the Nd isotope ratio of seawater along the transect. In order to address fundamental questions on the Nd and REE cycle in the Pacific, the investigators

will also quantify boundary exchange effects, atmospheric inputs, provenance of particles, impacts of biological productivity, and fluxes into and out of seawater, in order to assess Nd and REE sources and sinks, and to calibrate Nd isotopes as a paleocirculation proxy in the Pacific. Specific focus areas include: (1) Nd isotopic characterization of the shallow and deep waters, (2) margin processes associated with the Alaska volcanic arc shelf, to study chemical exchanges between particulates, sediments, and seawater Nd isotopes and REE, (3) changing meridional dust sources and its impacts, (4) relationships between bottom sediment types, compositions, nepheloid layers, and their influence on the water column, (5) the effects of pore water flow on the water column; (6) the signal transfer between the deep water and sedimentary archives (e.g., fossil fish teeth, Fe-Mn oxide coatings). The project will advance the career of a postdoctoral research scientist, and support numerous undergraduate students.

[table of contents | back to top]

Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1434479
NSF Division of Ocean Sciences (NSF OCE)	OCE-1737318

[table of contents | back to top]